Combining Results of Independent Research in Tank
Crewman Performance

Barbara A. Black
U. S. Army Research Institute

Charlotte H. Campbell
Human Resources Research Organization

The effectiveness of any combat weapon system is in large measure a function of the level of performance of the soldier operator. The US Army is interested in ensuring maximum effectiveness of the new M1 tank system by optimally selecting and training M1 crewmen. To support the Army's effort in maximizing system effectiveness from the personnel selection aspect, the Army Research Institute has conducted extensive research in the area of tank crewman performance prediction during the past several years. The purpose of this paper is to evaluate the results of this research in order to determine by job content area, for both trainees and job incumbents, whether quantifiable aptitudes are related to tank gunnery performance.

Black and Kraemer (1981) identified three aptitude categories which potentially underlie gunnery performance. These included a cognitive component as encountered in troubleshooting, a perceptual component as in target acquisition and a psychomotor/perceptual-motor component as in target tracking. Each of the four crew positions within the tank system (i.e., loader, driver, gunner and tank commander) requires performance of tasks which appear to contain these components, albeit in varying degrees. A review of the Armor crewman performance prediction literature lends support to this categorization but points to an additional dichotomy with reference to research techniques utilized. Techniques include paper-and-pencil tests as well as tests called job samples which require either simulators or actual tank equipment.

These aptitude categories and research techniques were identified in the tank crewman performance prediction literature. In the area of cognitive testing, the literature included validation of ASVAB-derived composite scores such as CO, GT and AFQT as paper-and-pencil predictors of gunnery performance (Greenstein & Hughes, 1977; Campbell & Black, 1982; Black, in preparation), and simulator based tests of the tank fire control computer (Campbell & Black, 1982; Black, in preparation). For perceptual testing, paper-and-pencil tests are also the most commonly encountered (Greenstein & Hughes, 1977; Eaton, 1978; Eaton, Bessemer, & Kristiansen, 1979), although two instances of simulator based perceptual tests were found (Eaton, Johnson, & Black, 1980; Campbell & Black, 1982). Validation of psychomotor tests using hands-on equipment can be found in three reports (Eaton, 1978; Kress, 1980; Black, in preparation), and finally, simulation techniques are applied to psychomotor performance prediction in two reports (Eaton et al., 1980; Campbell & Black, 1982; Black, in preparation). The correlations reported for these research efforts provided the data for the meta-analyses.

Method

The eight documents included in the review of Armor crewman performance prediction literature produced a total of 18 data sets for evaluation. Data sets were accepted for meta-analysis based upon the following criteria:

1) predictor variables were obtained from tests which could be classified as either cognitive, perceptual or psychomotor/perceptual-motor, 2) criterion measures were tank live fire gunnery hit scores, and 3) subjects were either tank gunner trainees or operational unit gunner/TCs.

Data sets were placed into analytic categories according to the format presented in Table 1. Each data set had between one and ten correlations that were used in the meta-analyses for each analytic category.

Table
Number of Correlations (and Data Sets)
Available for Meta-Analysis

| APTITUDE | TEST TYPE | |
CATEGORIES	Paper-and-Pencil	Job Sample
Cognitive	18 (11)	8 (2)
Perceptual	63 (10)	6 (6)
Psychomotor or Perceptual-Motor	–	41 (11)

Two methods were used for combining and evaluating the results reported in the literature. The first, drawn from Rosenthal (1978), used exact probabilities (one-tailed) of the correlations to compute an overall Z for each data set; the exact probabilities were corrected for the number of correlations drawn from each data set in each analytic category. The Z-values for each data set in each category were then combined using a method whereby each Z is weighted by the degrees of freedom of its respective data set. The method yields a Z for each analytic category (see Table 2).

The second method was based on Glass (1977), who advocates the averaging of correlation coefficients or coefficients of determination. Here, the Fisher z-scores were computed for each correlation and combined (Snedecor & Cochran, 1967) first within data sets and then across data sets within each category to yield an overall weighted average z. This value was then converted back to a correlation; the squared correlations, representing the proportion of variance accounted for, are reported in Table 2.

Results and Discussion

While the aggregated results of cognitive paper-and-pencil testing produced a statistically significant cumulative Z for trainees, it is interesting to note that the average variance in gunnery scores accounted for by the cognitive component is only 2.5%. So although the predictions are consistent and reliable, they do not provide very much information. One variable of the cognitive job sample tests, computer accuracy, was a significant predictor for operational unit personnel, accounting for over 10% of the variance in gunnery performance, but the variable is not a significant predictor for trainees.

Table 2
Results of Two Meta-Analysis Techniques Relating
Tank Crewman Aptitudes to Tank Gunnery Performance

| | OPERATIONAL UNIT SOLDIERS | | TRAINEES | |
	Z	Variance Accounted for	Z	Variance Accounted for
COGNITIVE				
Paper & Pencil Tests	1.511	2.5%	2.171*	2.5%
Job Sample Tests				
.M1 Computer Accuracy	2.106*	10.6%	.977	0.4%
.M1 Computer Speed	-.627	2.5%	1.079	0.8%
PERCEPTUAL				
Paper & Pencil Tests	-6.741	0.0%	-4.957	0.1%
Job Sample Tests				
.Round Sensing	-	-	3.002***	4.8%
PSYCHOMOTOR/PERCEPTUAL-MOTOR				
Job Sample Tests				
.Tracking Accuracy	1.441	6.0%	1.266	1.0%
.Tracking Speed	-.122	0.0%	1.388	0.9%
.Main Gun Lay Accuracy	2.542**	7.1%	-	-
.Main Gun Lay Speed	2.239*	4.9%	-	-
.Target Engag. Hits	-.433	0.1%	.581	0.1%
.Target Engag. Speed	-	-	.245	0.0%
.Sub-Caliber Hits	-.239	0.1%	-	-
.Sub-Caliber Speed	1.547	4.0%	-	-

*p < .05 one-tailed
**p < .01 one-tailed
***p < .001 one-tailed

Perceptual paper-and-pencil tests were poor predictors of gunnery scores for both operational unit personnel and trainees. The job sample test approach, however, produced positive correlations in all data sets, for a highly significant effect, but the variance accounted for averages less than 5%. Whether the approach would be effective among operational unit personnel is unknown. Two of the job sample tests of psychomotor/perceptual-motor aptitude were significant predictors across studies for operational unit soldiers, but none was a predictor for trainees.

Overall, it would appear that job sample tests are better predictors of performance by job incumbents than are paper-and-pencil techniques. For trainees, however, where performance is usually measured during their earliest experience on the tank, hands-on tests are sometimes predictive, and so are paper-and-pencil tests. It should be noted that no attempt was made to separate concurrent predictions and actual time-separated predictions for the analyses of unit personnel performance. And because perceptual paper-and-pencil tests were combined within data sets and adjusted for that process of combining, the large numbers of small correlations in each data set caused the combined Zs for the sets to be very large negative numbers. Examination

of individual tests across research efforts could lead to different conclusions for a few. In general, meta-analysis techniques appear to be valuable tools in assimilating independent research results and providing insight for future research efforts.

References

Black, B. A. M1 Crewman Gunnery and Training Performance Prediction (Research Product). Fort Knox, Kentucky: US Army Research Institute for the Behavioral and Social Science, in preparation.

Black, B. A., & Kraemer, R. E. XM1 Gunnery Training and Aptitude Requirements Analyses (Research Product 81-5). Fort Knox, Kentucky: US Army Research Institute for the Behavioral and Social Sciences, 1981.

Campbell, C. H., & Black, B. A. Predicting Trainability of M1 Crewmen (Final Report FR-MTRD(KY)-82-7). Fort Knox, Kentucky: Human Resources Research Organization, 1982.

Eaton, N. K. Predicting Tank Gunnery Performance (Research Memorandum 78-6). Fort Knox, Kentucky: US Army Research Institute for the Behavioral and Social Sciences, 1978.

Eaton, N. K., Bessemer, D. W., & Kristiansen, D. M. Tank Crew Position Assignment (Technical Report No. 391). Fort Knox, Kentucky: US Army Research Institute for the Behavioral and Social Sciences, 1979.

Eaton, N. K., Johnson, J., & Black, B. A. Job Samples as Tank Gunnery Performance Predictors (Technical Report No. 473). Fort Knox, Kentucky: US Army Research Institute for the Behavioral and Social Sciences, 1980.

Glass, G. V. Integrating findings: The meta-analysis of research. Review of Research in Education, 1977, 5, 351-379.

Greenstein, R. B., & Hughes, R. G. The Development of Discriminators for Predicting Success in Armor Crew Positions (Research Memorandum 77-27). Fort Knox, Kentucky: US Army Research Institute for the Behavioral and Social Sciences, 1977.

Kress, G. Validation of Tank Gunnery Training Tasks (Draft Final Report MDA 903-78-C-2042). Alexandria, Virginia: Human Resources Research Organization, 1980.

Snedecor, G. W., & Cochran, W. G. Statistical Methods (6th ed.) Ames, Iowa: Iowa State University Press, 1967.